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Prepared by the
Forest Insect Laboratory
Missoula, Montana

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HISTORY

A large section of the Coal Creek drainage in Glacier National Park, Montana was burned by a forest fire on August 13, 1958. The fire burned for three days. Each afternoon it became intense, crowned frequently, and consumed all ground vegetation as it spread rapidly. Trees on about 2,500 acres of mixed coniferous timber types were either killed or scorched before the fire was controlled. The Missoula Forest Insect Laboratory was requested by Park Superintendent Edward A. Hummel to ascertain the possibility of the scorched trees serving as a breeding place for tree-killing bark beetles that might eventually damage nearby living stands.

Analysis of colored photographs and of notes taken during a flight over the burned site in October 1958 indicated that scorched trees would have to be kept under surveillance for several years before their full potential as insect-breeding media could be determined. In addition to inspecting trees for insects, it seemed practical to collect data that could be used to study the relationship between the occurrence of mixed conifer trees damaged by fire and any subsequent insect populations developing in them. Hardly any research has been done on this subject in the northern Rocky Mountain region.

Inspections of the Coal Creek Burn were made in July 1959 and August 1960 to (1) record the species and abundance of tree-killing insects that might infest scorched trees, (2) determine the succession of insect species in scorched trees that became infested, and (3) record the amount of damage to nearby unburned trees caused by insects bred in scorched trees or attracted to the burned area.

PROCEDURE

The boundaries of a 150-acre sampling area were established in July 1959 on the north and south sides of a fire-line road that extended along the southern part of Section 22; T.31N.; R.16W; M.P.M. Six survey strips were established at ten-chain intervals along the road. The strips averaged 20 chains in length and extended through areas containing trees that had been either killed by the fire, heavily to lightly scorched, or unburned. A 1/10-acre plot was placed every two chains along the strips. One tree in the center of each plot was marked with yellow paint to make it possible to locate the plot in subsequent examinations. Altogether, the study area contained 71 plots. The arrangement of strips and plots was planned to aid in detecting insect infestations that might develop in nearby unburned timber due to insect population buildups in fire-weakened trees.

Data were collected from the plots during July 1959, and August 1960. The following information was obtained for every tree on each plot: (1) species, (2) diameter at breast height for trees over 4 inches d.b.h., (3) degree of fire injury, (4) species of insects infesting the bole up to seven feet above the ground, (5) amount of bole circumference infested at breast height, and (6) a measurement of insect population density in the infested portion of the bole seven feet above the ground level.

The relative amount of damage to each tree caused by the fire was assessed according to a system of ocular appraisal developed by Miller and Patterson[1/] with some modifications made to adapt it to conditions in the Coal Creek area. The system recognizes 5 classes of fire injury to trees that may be recognized up to one year following the fire:

Class of fire injury		Condition of foliage	Probability of survival
I	Uninjured	Green	
II	Lightly scorched	$\frac{3}{4}$ crown green	Excellent
III	Moderately scorched	$\frac{1}{2}$ crown green	Fair
IV	Heavily scorched	$\frac{1}{4}$ crown green	Uncertain
V	Killed	Reddish-brown	

1/ Miller, J. M., and J. E. Patterson. 1927. Preliminary studies of the relation of fire injury to bark beetle attack in western yellow pine. Jour. Agr. Res. 34(7).

RESULTS

Abundance of conifers on plots

A total of 1,419 trees comprising six species of conifers were checked for the presence of insects on the 71 one-tenth-acre plots during August 1960. Subalpine fir was the most abundant species, followed by Engelmann spruce, western white pine, Douglas-fir, lodgepole pine, and western larch in that order. Over half of these trees grew on plots outside the fireline and were uninjured. However, a few trees in the burned area also escaped injury. These were therefore rated as Class I. About one-third of the trees were killed (Class V), and the remaining trees were scorched by the fire (Classes II-IV), (table 1).

Table 1.--Number of trees on 71 one-tenth-acre sample plots classified by degree of fire injury in 1959

Tree species	Classes of fire injury					Totals
	I	II	III	IV	V	
Douglas-fir	52	39	13	9	86	199
Engelmann spruce	199	13	5	5	43	265
Lodgepole pine	70	3	2	1	27	103
Subalpine fir	317	3	4	6	284	614
Western larch	12	3			2	17
Western white pine	197	6	2	4	12	221
Totals	847	67	26	25	454	1,419

Diameters of conifers on plots

As a group, lightly scorched Class II trees were those with the largest average diameter (d.b.h.) (table 2). This is reasonable to expect because the crowns of the largest dominant trees usually suffer less injury from ground fires. Subalpine fir trees had the smallest average diameters while western larch trees averaged the largest. It is interesting to note from table 2 that the average diameters for Classes I, III, IV, and V are nearly the same, indicating fairly uniform diameter distribution regardless of injury class. Trees from 4 to 8 inches in diameter predominated on the plots.

Table 2.--Distribution of trees by average diameter and class of fire injury on sample plots in 1959

Tree species	I	II	III	IV	V	Means
Douglas-fir	12.2	16.1	10.9	11.1	10.5	12.1
Engelmann spruce	9.3	7.8	6.0	8.4	7.8	7.9
Lodgepole pine	10.9	12.0	14.0	16.0	12.4	13.1
Subalpine fir	5.0	9.3	7.5	7.0	6.2	7.0
Western larch	20.5	26.6	---	---	19.0	22.0
Western white pine	6.4	13.0	11.0	11.0	9.0	10.1
Means	10.7	14.1	9.9	10.7	10.8	

Insect species abundance by fire-injury classes

The insects collected from trees on the sample plots during 1959 and 1960 and the frequency with which these species were found in the six species of conifers are listed by fire injury class in tables 3 and 4.

Wood-boring beetles belonging to the families Buprestidae and Cerambycidae and represented by the four species listed in table 3, have been the most prevalent insects found under the bark of killed and scorched trees since the fire in 1958. Altogether, 71 percent of all trees infested by insects contained wood borers. In contrast, borers made up only a part of the insects that attacked the following species of scorched or fire=killed trees, i.e., 76 percent in Douglas-fir, 55 percent in lodgepole pine, and 50 percent in Engelmann spruce and western white pine. Borers were most prevalent in Class II and III trees.

The Douglas-fir beetle, one of the most important insect pests of Douglas-fir trees in Montana, infested 10 percent of all trees of this species on the study plots. Trees in Class II were found to be infested by this beetle with greater frequency than those in other fire-injury classes. One tree in Class I was attacked, illustrating this insect's capability to infest and kill green trees.

Species of Ips beetles were collected from 10 percent of the 143 trees infested by insects on the plots. Ips guildi seemingly preferred lodgepole pine trees that had been killed by the fire, and Ips engelmanni was most abundant in Engelmann spruce trees with Class II fire injury.

The mountain pine beetle was found in 4 pine trees--two killed by the fire and two lightly scorched.

Table 3.--Prevalent insect species collected from conifers damaged by fire on sample plots during 1959 and 1960

Host tree species	d.b.h. (inches)	Fire injury class	Common name of insect	Scientific name of insect*
Douglas-fir	12	V	Flatheaded fir borer	Melanophila drummondi Kby.
Douglas-fir	38	II	Douglas-fir beetle	Dendroctonus pseudotsugae Hopk.
Douglas-fir	14	IV	A roundheaded borer	Xylotrechus undulatus (Say)
Engelmann spruce	6	III	A spruce engraver beetle	Ips engelmanni Sw.
Lodgepole pine	12	V	A flatheaded borer	Dicerca tenebrosa (Kby.)
Lodgepole pine	14	V	A pine engraver beetle	Ips guildi Blkm.
Subalpine fir	10	V	Oregon fir sawyer	Monochamus oregonensis Lec.
Western white pine	6	II	A pine engraver beetle	Ips hunteri Sw.
Western white pine	18	II	Mountain pine beetle	Dendroctonus monticolae Hopk.
Western white pine	12	IV	A pine twig beetle	Pityophthorus sp.

* Tentative identifications.

Table 4.--Insects present in six species of conifers listed by classes of fire injury on sample plots from August 1958 to August 1960

Tree species	Total no. of trees on plots	Classes of fire injury																Totals	Percentage of trees attacked
		I	II					III		IV				V					
		Numbers of trees attacked by the following insects:																	
		Douglas-fir beetle	Ips spp.	Douglas-fir beetle	Mtn. pine beetle	Ips spp.	Wood borers	Douglas-fir beetle	Wood borers	Douglas-fir beetle	Ips spp.	Wood borers	Scolytidae	Douglas-fir beetle	Mtn. pine beetle	Ips spp.	Wood borers		
Douglas-fir	199	1		10			17	1	8	1		5	1	7			38	89	44.7
Engelmann spruce	265		1			4	1									1	5	12	4.5
Lodgepole pine	103		2				1								1	5	9	18	17.5
Subalpine fir	614						1					1					9	11	1.8
Western larch	17						1											11	5.9
W. white pine	221				2	1	3				1	1	1		1		2	12	5.4
Totals	1,419	1	3	10	2	5	24	1	8	1	1	7	2	7	2	6	63		10.1 (Ave.)

Only 143 of the 1,419 trees on the plots were attacked by insects, but 62 percent of these infested trees were Douglas-firs. Field data indicated that Class IV and Class III Douglas-fir trees were more frequently infested by insects than those in other fire-injury classes; also that insects attacked trees from 8 to 14 inches in diameter more often than trees of other diameters.

To summarize, trees in some fire-injury classes were found to be infested by insects more frequently than those in other classes:

Fire-injury class	Percentage of trees infested	Order of frequency
II	61.0	1
IV	44.0	2
III	35.0	3
V	17.0	4
I	0.4	5

Insect Abundance in 1960

Information on insect activity in the Coal Creek burn presented in previous paragraphs has dealt with that occurring during the 2-year period following the fire. To determine whether insect-infested trees are increasing or decreasing in number each year since the fire, those infested in 1960 are shown in table 5.

Table 5.--Summary of current insect infestations in six species of conifers damaged by fire on sample plots in August 1960

species	Total no. of trees on plots	No. of trees infested with the following insects: Douglas-fir beetle	Ips spp.	Wood borers	A Scolytid	Totals
Douglas-fir	199	9		52	1	62
Engelmann spruce	265		2	1		3
Lodgepole pine	103		3	1		4
Subalpine fir	614			3		3
Western larch	17			1		1
W. white pine	221		1	1	1	2
Grand totals	1,419	9	6	59	1	75

Three groups of insects were largely responsible for the infestation of trees in this year--wood borers, the Douglas-fir beetle, and a few miscellaneous bark beetles. The importance of these groups in 1959 and 1960 may be seen in comparison:

Insects	Number of trees infested 1959	1960
Wood borers	43	59
Douglas-fir beetle	11	9
Misc. bark beetles	14	7
	68	75

DISCUSSION

The chief concern following the Coal Creek fire of August 1958 was the threat to nearby uninjured timber of a buildup and spread of tree-killing bark beetles in fire-scorched Douglas-fir, Engelmann spruce, lodgepole pine, and western white pine trees.

Large numbers of tree-killing beetles have not developed in the burn. A small population of Douglas-fir beetles now present will probably not increase because wood borers, which pose no harm to green trees, are rapidly rendering remaining scorched trees unsuitable for a breeding medium by the fir beetle. Wood borers do, however, reduce the timber salvage value of scorched trees in commercial forests.

Other species of bark beetles (Ips, Pityophthorus, and an unknown) occurred in some trees, but these are relatively unimportant as tree pests and are of academic interest only.

Although there was little difference in the number of trees infested in the burn in 1959 and 1960, the number is expected to decrease in 1961 as the susceptible scorched trees either recover in vigor or deteriorate by weathering or fungus infection to the point where they no longer attract insect attacks.

There are records of tree-killing bark beetles, particularly the western pine beetle, developing epidemic numbers in fire-scorched ponderosa pine trees in Oregon, Idaho, and California. However, these epidemics occurred in or adjacent to burned stands of pure ponderosa pine. Results of the study in the Coal Creek Burn to date seem to indicate that stands with mixed species of fire-scorched timber may not be important breeding places for tree-killing beetles in that area.